$2.50

Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

SIMPSON 465 SERIES 2 AUTORANGING DIGITAL MULTIMETER

WARNING

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

SIMPSON ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

DIGITAL INSTRUMENT
Warranty

SIMPSON ELECTRIC COMPANY warrants each digital instrument manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any digital instrument which shall within one (1) year after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any digital instrument which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

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KATY INDUSTRIES
ELECTRICAL EQUIPMENT GROUP

OPERATOR'S MANUAL

SIMPSON 465 SERIES 2 AUTORANGING DIGITAL MULTIMETER

This symbol on the nameplate means the product is Listed by Underwriters Laboratories Inc.

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NOTE: This Operator's Manual contains information essential to the operation of this Instrument. Therefore, it should be kept in a convenient place and used for reference as required.

SAFETY SYMBOLS

This marking adjacent to another marking or a terminal or operating device indicates that the Operator must refer to an explanation in the Operating Instructions to avoid damage to the equipment and/or to avoid personal injury.

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which if not correctly performed or adhered to, could result in personal injury.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which if not correctly adhered to could result in damage to or destruction of part or all of the Instrument.

WARNING

This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

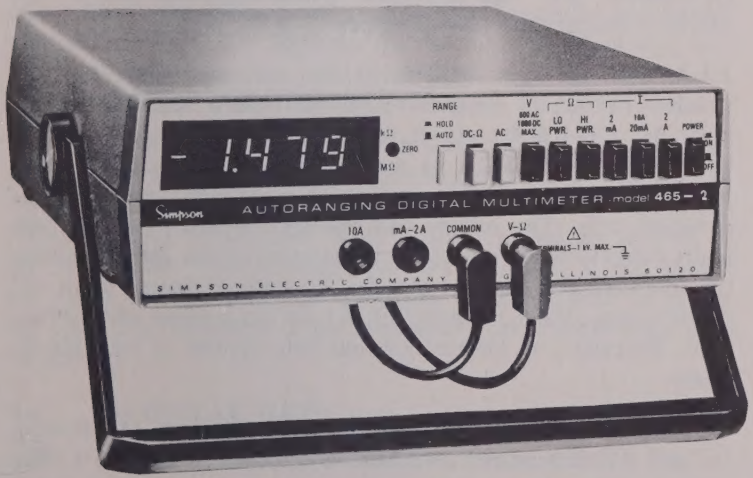


Figure 1-1. Simpson 465 Series 2 Autoranging Digital Multimeter

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson 465 Series 2 Digital Multimeter (hereafter referred to as the 465-2 or simply as the Instrument) is a versatile 3½ digit autoranging instrument suitable for use in general electronic maintenance, production, and laboratory. It features 0.1% DCV accuracy, integrated circuit electronics, solid-state LED display, and pushbutton switch selection. A special HOLD function is provided to enable the user to perform repeated measurements without changing ranges. Additional features are automatic polarity, separate "low" and "standard" power resistance ranges, and excellent temperature characteristics.

1.1.2 The 465-2 is available in two versions: 465A-2 is the standard instrument designed to operate from a 120, 220 or 240 volts AC (50-400Hz) power source (check rear panel designation); and the 465D-2 is an optional version designed for either AC line operation, or battery operation using rechargeable nickel-cadmium cells. The battery can operate the Instrument for ten hours continuously. Recharging is automatic when the Instrument is in the OFF position and with the line cord connected to an AC power source. Refer to paragraph 6.4 for precautions and instructions. Hereafter, all information and data applies to both instruments.

1.1.3 The 465-2 (Figure 1-1) measures DC and AC voltage, DC and AC current and resistance as specified in Table 1-1. The up-down integration technique is used for the analog-to-digital (A/D) conversion because of its inherently excellent stability, accuracy, and noise immunity. The use of a Simpson custom MOS-LSI integrated circuit achieves high reliability, low power dissipation, and a compact design.

1.1.4 The numerical display is a 7-segment light-emitting-diode

(LED) display for easy viewing and solid-state reliability. The numerals are 0.43 inch high and in a single plane for distant and wide-angle viewing. Ambient lighting effects are minimized by a filter which reduces reflections and background illumination. A special display feature of automatic blanking of unused digits is incorporated to conserve battery power and to improve display readability.

1.2 SUPPLIES AND ACCESSORIES

1.2.1 All supplies and accessories required for the operation of the 465-2 (using line power) are furnished with the Instrument and listed in Table 6-2. Batteries for the 465D-2 are not supplied.

1.3 SAFETY CONSIDERATIONS

1.3.1 This Operator's Manual contains cautions and warnings alerting the user to hazardous operating and service conditions. This information is flagged by CAUTION or WARNING headings throughout this publication, where applicable, and are defined at the front of the manual under SAFETY SYMBOLS. To ensure the safety of operating and servicing personnel and to retain the operating conditions of the instrument these instructions must be adhered to.

1.4 TECHNICAL DATA

1.4.1 Table 1-1 lists the technical data for the 465-2.

Table 1-1. Technical Data

1. AUTORANGING DC VOLTAGE:

Range	Maximum Indication	Input Resistance	Overload Protected To
.2V	±.1999V	10 MΩ	±1000 VDC
2V	±1.999V	10 MΩ	±1000 VDC

20V	±19.99V	10 MΩ	±1000 VDC
200V	±199.9V	10 MΩ	±1000 VDC
1000V	±1000 V (Max. Input)	10 MΩ	±1000 VDC

Accuracy (from +15°C to +35°C): ±(0.1% of reading + 1 digit)

Input Bias Current: 10 pA at reference conditions

Sensitivity: 100μV

Full Range Step Response (to rated accuracy): 2 Seconds

Normal Mode Rejection: 50 dB minimum at 60 Hz

Common Mode Rejection: 90 dB minimum at 60 Hz with 1,000 Ω unbalance

Temperature Coefficient (from 0°C to +55°C): ±(0.01% of reading + 0.1 digit)/°C

2. AUTORANGING AC VOLTAGE:
(Average-Sensing, rms Calibrated Sine Wave)

Range	Maximum Indication	Input Impedance	Frequency Range	Overload Protected To
.2V	.1999V	10 MΩ and 25 pF	40Hz-20kHz	600V rms
2V	1.999V	10 MΩ and 25 pF	40Hz-20kHz	600V rms
20V	19.99V	10 MΩ and 25 pF	40Hz-20kHz	600V rms
200V	199.9V	10 MΩ and 25 pF	40Hz-20kHz	600V rms
600V	600V (Max. Input)	10 MΩ and 25 pF	40Hz-1kHz	600V rms

Accuracy (from +15°C to +35°C):

.2V, 2V and 20V ranges:
±(0.5% of reading + 2 digits), 40Hz to 10kHz
±(1.0% of reading + 2 digits), 10kHz to 20kHz

200V range:
±(0.5% of reading + 2 digits), 40Hz to 1kHz
±(1.0% of reading + 2 digits), 1kHz to 20kHz

600 V range:
±(2% of reading + 2 digits), 40Hz to 1kHz

Sensitivity: 100μV

Full Range Step Response (to rated accuracy): 7 seconds

Temperature Coefficient
(from 0°C to +55°C): ±(0.05% of reading + 0.2 digit)/°C

3. AUTORANGING RESISTANCE:
(High or Standard Power Ohms)

Range	Maximum Indication	Max. Open Circuit Voltage	Overload Protected To
2 kΩ	1.999 kΩ	2.5V	130 VAC or DC
20 kΩ	19.99 kΩ	2.5V	130 VAC or DC
200 kΩ	199.9 kΩ	2.5V	130 VAC or DC
2000 kΩ	1999 kΩ	2.5V	130 VAC or DC
20 MΩ	19.99 MΩ	2.5V	130 VAC or DC

Accuracy (from +15°C to +35°C): ±(0.4% of reading + 2 digits) except on the 20 MΩ range, which is ±(1.0% of reading + 3 digits)

Sensitivity: 1 ohm

Full Range Step Response
(to rated accuracy): 3 seconds, except on 20 MΩ range, which is 7 seconds

Temperature Coefficient
(from 0°C to +55°C): ±(0.04% of reading + 0.1 digit)/°C

4. AUTORANGING RESISTANCE:
(Low Power Ohms)

Range	Maximum Resistance	Max. Open Circuit Voltage	Overload Protected To
2 kΩ	1.999 kΩ	350 mV	130 VAC or DC
20 kΩ	19.99 kΩ	350 mV	130 VAC or DC
200 kΩ	199.9 kΩ	350 mV	130 VAC or DC
2000 kΩ	1999 kΩ	350 mV	130 VAC or DC

Accuracy (from +15°C to +35°C): ±(0.4% of reading + 2 digits)

Sensitivity: 1 ohm

Full Range Step Response
(to rated accuracy): 3 seconds

Temperature Coefficient
(from 0°C to +55°C): ±(0.04% of reading + 0.1 digit)/°C

5. AUTORANGING DC CURRENT:

Range	Maximum Indication	Full Range Voltage Drop	Overload Protected To
	DC Current, 2 mA		
.2 mA	±.1999 mA	200 mV	30 mA
2 mA	±1.999 mA	2 V	30 mA
	DC Current, 20 mA		
20 mA	±19.99 mA	200 mV	2 A
	DC Current, 2A		
.2 A	±.1999 A	200 mV	2 A
2 A	±1.999 A	2 V	2 A
	DC Current, 10A		
10 A	±10.00 A	100 mV	10 A

Accuracy (from +15°C to +35°C): ±(0.25% of reading + 1 digit), except on 10A range, which is ±(1.0% of reading + 2 digits).

Sensitivity: 100 nA

Full Range Step Response: 2 seconds

Temperature Coefficient (from 0°C to +55°C): ±(0.05% of reading + 0.1 digit)/°C

6. AUTORANGING AC CURRENT:

Range	Maximum Indication	Full Range Voltage Drop	Frequency Range	Overload Protected To
	AC Current 2 mA			
.2 mA	.1999 mA	200 mV	40 Hz-5kHz	30 mA
2 mA	1.999 mA	2 V	40 Hz-5kHz	30 mA
	AC Current 20 mA			
20 mA	19.99 mA	200 mV	40 Hz-5kHz	2 A
	AC Current 2 A			
.2 A	.1999 A	200 mV	40 Hz-5kHz	2 A
2 A	1.999 A	2 V	40 Hz-5kHz	2 A
	AC Current 10 A			
10 A	10.00 A	100 mV	40 Hz-5kHz	10 A

Accuracy (from +15°C to +35°C):	±(1.0% of reading + 2 digits), except on 10A range, which is ±(1.5% of reading + 2 digits)
Sensitivity:	100 nA
Full Range Step Response (to rated accuracy):	5 seconds
Temperature Coefficient (from 0°C to +55°C):	±(0.1% of reading + 0.1 digit)/°C

7. RATED CIRCUIT-TO-GROUND VOLTAGE (Maximum Common Mode Voltage): 1000-volts (DC plus peak AC) maximum from any measuring terminal to powerline (earth) ground terminal, except on 10A ranges, which is 50 volts maximum.

8. RESOLUTION: 1 part in 2000

9. ZERO STABILITY: ±0.02% of range/°C (adjustable to zero with front panel control).

10. DISPLAY:

Numerical Display:	3½ digit, 7-segment light-emitting-diode (LED) type, Automatic blanking of non-significant leading zeros.
Conversion Rate:	4 readings per second, nominal.
DC Polarity Selection:	Automatic with "+" or "—" indication.
Ranging: Auto	Automatically upranges for readings 2000 counts and above; downranges for readings below 180 counts.
Hold	Fix measurement in a single range.

11. POWER REQUIREMENT:

AC Operating or Battery Charging:	120 VAC, 220 VAC, or 240 VAC ±10% (check rear panel designation), 50-400 Hz 6 VA nominal.
Battery Operation:	Four nickel-cadmium "D" size rechargeable cells, Eveready type CH4 or equivalent (each cell is rated at 1.25V, 4 ampere-hours).

Battery Operation Time (continuous with fully charged battery):	10 hours, nominal.
Batery Recharge Time:	16 hours, nominal.

12. TEMPERATURE RANGE:

Operating:	0°C to +55°C
Storage:	−40°C to +60°C

13 REFERENCE CONDITIONS:

Temperature:	+23°C, ±1°C
Relative Humidity:	30 to 60%
Atmospheric Pressure:	575 to 800 mmHg

14. DIMENSIONS:

Height:	2.70 in. (68.6 mm)
Width:	8.40 in. (213.4 mm)
Depth:	9.00 in. (228.6 mm)

15. WEIGHT: Approximately 3 lbs. (1.36 kg)
5 lbs. (2.26 kg) with battery installed.

Table 1-2. Items and Accessories Furnished With This Instrument

Quantity	Description	Part No.
1	Test Lead Set: One black and one red insulated lead having probe tips with provisions for screw-on alligator clips (one red and one black supplied).	10-830673
1	Power Cord	5-118916
1	Operator's Manual	6-110883

SECTION II
INSTALLATION

2.1 GENERAL

2.1.1 This section contains information and instructions for the installation and shipping of the 465-2. Included are unpacking and inspection procedures, warranty, shipping, power source requirements, installation, and care.

2.2 UNPACKING AND INSPECTION

2.2.1 Examine the shipping carton for any sign of damage. Inspect the Instrument and packing material for obvious damage from mechanical shock, water leakage, or other causes. Check the electrical performance as soon as possible. If there is any indication of damage, file a complaint with the carrier immediately. Also check that all accessories are included (Table 1-2). Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.3 WARRANTY

2.3.1 The Simpson Electric Company warranty policy is printed on the inside front cover of this manual. Read it carefully prior to requesting a warranty repair.

> **NOTE:** For assistance of any kind, including help with the Instrument under warranty, contact the nearest Authorized Service Center for instructions (listed on the last pages of this manual). If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number, serial number (at the back of the Instrument) and date of purchase. Service data or shipping instructions will be mailed promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will

be quoted. This charge will not be exceeded without prior approval.

2.4 SHIPPING

2.4.1 Pack the Instrument carefully and ship it prepaid to the proper destination. Insure the Instrument.

2.5 POWER SOURCE REQUIREMENTS

2.5.1 The 465A-2 is designed to be operated from the AC line only. The 465D-2 is designed to be operated from either the AC line or self-contained nickel-cadmium cells (not furnished with the Instrument but available from any local electronic parts distributor). Refer to Table 1-1, item 11.

2.5.2 AC Line Operation: The 465-2 is wired at the factory for 120 VAC (50 to 400 Hz) operation. To convert your Instrument for 220 or 240 VAC operation, consult the nearest Authorized Service Center (listed on the last pages of this manual).

CAUTION

For AC line operation, ensure that the grounding pin of the power plug is securely connected to an earth (power-line) ground. Use a 3-wire grounded outlet which conforms to the latest issue of the National Electrical Code.

2.5.3 Battery Operation (465D-2): Battery operation is automatic whenever cells are installed, the line cord is disconnected, and one of the function switches set to a position other than the POWER OFF position. For battery installation and battery test refer to paragraph 6.3.

2.6 INSTALLATION

2.6.1 The Instrument may be set horizontally on its four rubber feet or vertically on its back and operated in either position. The Instrument can also be set at an inclined angle by positioning the 8-position carrying handle under the unit. To set the Instrument at a desirable viewing angle, use the following procedure.

a. Pull out both knobs on sides of Instrument.

b. Rotate handle to one of eight positions.

c. Push both knobs into a locking position.

2.7 CARE

WARNING

Do not attempt to clean this Instrument with the test leads connected to a power source or when it is connected to the AC powerline.

2.7.1 Immediately clean all spilled materials from the Instrument and wipe dry. If necessary, moisten a cloth with soap and water to clean plastic surfaces.

2.7.2 Do not allow the battery to fully discharge. A completely discharged battery will eventually become inoperative if allowed to discharge repeatedly. In such a case, replacement will be necessary. Check the battery voltage according to paragraph 4.3.2.

2.7.3 Whenever possible, avoid exposure or usage in areas which are subject to temperature and humidity extremes, vibration or mechanical shock, dust or corrosive fumes or strong electrical or electromagnetic interferences.

2.7.4 Monthly Care: Verify Instrument calibration by perform-

ing operational checks using known value sources. If the need for calibration is indicated, contact the nearest Authorized Service Center.

2.7,5 Annual Care: It is recommended that the Instrument be returned annually to an Authorized Service Center or the factory for a complete overall check and calibration.

2.7.6 Storage: When the Instrument is not in use, store it in a location free from temperature extremes, dust and corrosive fumes, and mechanical vibration or shock.

SECTION III
CONTROLS, CONNECTORS, AND INDICATORS

3.1 GENERAL

3.1.1 All operating and adjusting controls, connectors and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

3.2 FRONT AND REAR PANEL DESCRIPTION

3.2.1 Table 3-1 lists all front and rear panel controls, connectors and indicators (Figure 3-1 and 3-2 for identification).

Table 3-1. Front and Rear Panel Description

1. POWER Switch:	
ON	Applies primary power to the Instrument.
OFF	Disconnects primary power from all circuits except the battery charging circuit.
2. RANGE Switch:	
HOLD	Locks the Instrument in a single range — the same range as when the HOLD switch was depressed.
AUTO	Permits the Instrument to operate in the automatic ranging mode.
3. DC-Ω Switch:	Selects the DC voltage, DC current or resistance measuring circuits, depending on the function switch position setting.
4. AC Switch:	Selects the AC voltage or AC current measuring circuits, depending on the function switch position setting.
5. V Switch:	
600 AC 1000 DC MAX	Selects voltage function for either 0 to 600 VAC or 0 to 1000 VDC voltage measurement, depending on selection of DC-Ω or AC switch.
6. Ω Switches:	
LO PWR	Selects the "low power" resistance function for 0 to 2000kΩ.

HI PWR	Selects the standard resistance function for 0 to 20 MΩ.
7. I Switches:	
2 mA	Selects full range current measurements of 0 to ±0.2mA DC, 0 to 0.2mA AC, 0 to ±2mA DC, or 0 to 2mA AC, depending on selection of DC-Ω or AC switch.
10 A 20 mA	Selects full range current measurements of 0 to ±20mA DC, 0 to 20mA AC, 0 to ±10A DC, or 0 to 10A AC, depending on selections of DC-Ω or AC switch and input connections. See Table 4-1.
2 A	Selects full range current measurements of 0 to ±0.2A DC, 0 to 0.2A AC, 0 to ±2A DC, or 0 to 2A AC, depending on selection of DC-Ω or AC switch.
8. ⚠:	Refer to Table 1-1, Item 7.
9. V-Ω Jack:	This terminal is used to connect the "high" side of the circuit being measured to all voltage and resistance measuring circuits.
10. COMMON Jack:	This jack is used to connect the "low" side of the circuit measured to the internal circuit COMMON and is isolated from the AC power-line ground.
11. mA-2A	This terminal is used to connect the "high" side of the currents being measured to the current measuring circuits. The "low" side is connected to the COMMON jack.
12. 10A Jack:	This terminal is used to connect the "high" side of the 10 ampere full scale current being measured to the current measuring circuits when the I 10A and 20mA switch is selected. The "low" side is connected to the COMMON jack.
13. BATTERY TEST 4.7-6V: (465D-2 only)	For battery test, connect a test lead between the V-Ω jack and the BATTERY TEST jack, with the V and DC-Ω switches selected. The numerical display must indicate a voltage between +4.7 volts and +6.0 volts for proper operation.

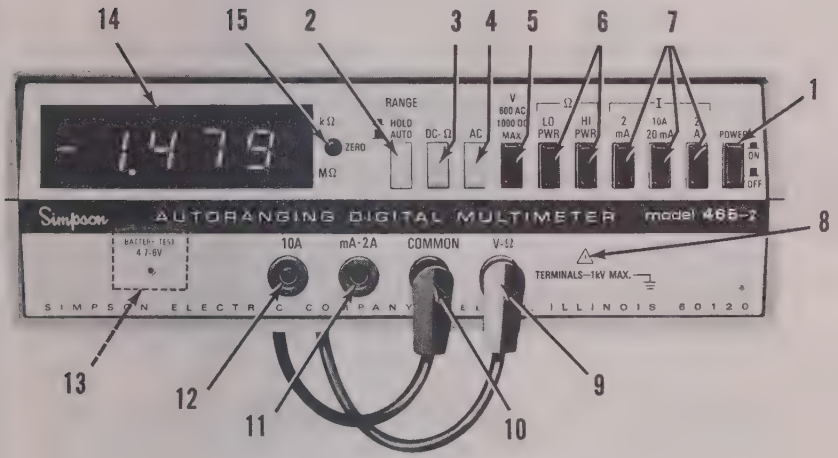


Figure 3-1. Front Panel Description

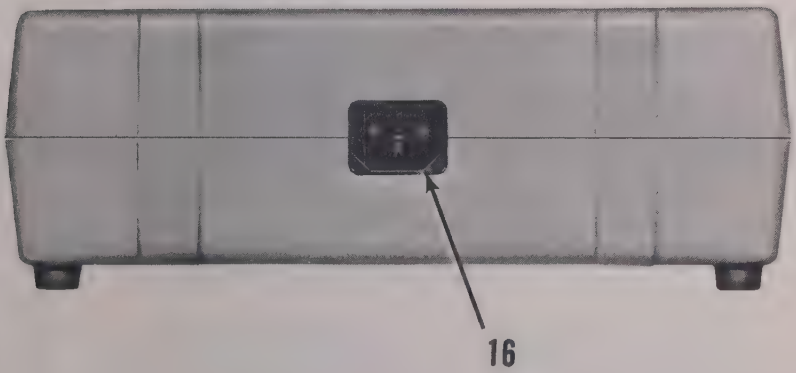


Figure 3-2. Rear Panel Description

14. Numerical Display: The digital display uses LED's and includes a minus polarity (—) sign, four 7-segment type 0 to 9 digits and a decimal point, to indicate the polarity and the value of the signal being measured. The decimal point is properly positioned by the selection of the range switch. Over-range (or out-of-range) condition is indicated by a flashing "2" display for 2000 counts or greater.

15. ZERO Adjustment: This adjustment is a screwdriver-adjusted potentiometer used to correct for a DC offset voltage at the Input Amplifier. It is adjusted to obtain a numerical indication of .0000 when the Instrument is in the DC voltage mode, with the input leads shorted.

16. AC Power Receptacle: This receptacle accepts the AC line power cord used for AC operation or battery charging.

SECTION IV
OPERATION

4.1 GENERAL

WARNING

Before proceeding with the operation of the 465-2 review the SHOCK HAZARD printed at the front of this manual.

4.1.1 This section of the manual contains information required to use and operate the 465-2 in a safe and proper manner.

4.2 SAFETY PRECAUTIONS

4.2.1 The 465-2 is designed to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury.

4.2.2 Do not work alone when making measurements where a shock hazard can exist. Notify another nearby person that you are, or intend to make such measurements.

> **REMEMBER:** Voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured.

4.2.3 Locate all voltage sources and accessibility paths prior to making any measurements or connections.

4.2.4 Before each use, inspect the test leads, prods, connectors and power cable for cracks, breaks or crazes in the insulation. If any defects exist, destroy and replace the defective item(s) immediately.

4.2.5 Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates presence of high voltage, and probably a malfunction of some kind.

4.2.6 Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the test leads or the Instrument.

4.2.7 For maximum safety, do not touch test leads, circuit, or Instrument while power is applied to the circuit being measured.

4.2.8 Use extreme caution when making measurements in a circuit where dangerous composite voltages could be present, such as an rf amplifier.

4.2.9 Do not use test leads which differ from those originally furnished with the Instrument.

4.2.10 Before the Instrument is used for AC operation, make sure that the "third wire" on the AC power cord is connected to an earth or powerline ground.

4.2.11 Do not float any measuring terminal more than the rated circuit to ground voltage as specified in Table 1-1, item 7.

4.3 PRELIMINARY NOTES AND CHECKS

NOTE: Prior to operation of the Instrument, review and perform (where applicable) the following notes and checks. These steps can be used also as a general functional check.

4.3.1 For AC Line Operation:

a. Ensure that the power source used matches the requirements of the Instrument as marked on the rear panel.

b. Insert the plug into a 3-wire power outlet which conforms to the latest issue of the National Electrical Code. The 465D-2 will operate with or without battery power. When the 465D-2 is operating on the AC line with the internal battery installed, the battery is being "trickle" charged.

4.3.2 For the 465-2 battery operation follow this procedure:

CAUTION

For AC line operation, ensure that the grounding pin of the power plug is securely connected to an earth (power-line) ground. Use a 3-wire grounded outlet which conforms to the latest issue of the National Electrical Code.

a. Disconnect the AC line cord and set the POWER switch to the OFF position. Install four "D" size nickel-cadmium cells (not supplied with Instrument). Observe polarity as shown on label inside battery holder. Re-assemble case and turn power ON.

b. Depress the DC-Ω and V switches.

c. Connect a test lead between the V-Ω jack and the BATTERY TEST jack. The reading must be between +4.7 volts and +6.0 volts for proper operation of the Instrument.

d. If the battery voltage is below +4.7 volts, or if the display does not emit light, either the battery is improperly installed or re-charging is required.

4.3.3 To recharge the battery, follow this procedure:

a. Set the POWER switch to the OFF position. Connect the line cord plug into a 3-wire power outlet which conforms to the

power requirements of the Instrument as marked on the rear panel, and to the latest issue of the National Electrical Code.

b. The battery is being charged at full rate (≈ 400mA).

NOTE: If the battery test indicates a voltage below +4.7 volts (while the Instrument is ON), set the POWER switch in the OFF position for at least 15 minutes before operating.

4.4 GENERAL FUNCTIONAL CHECK

a. Review the safety precautions in paragraph 4.2.

b. Connect the black test lead to the COMMON jack and the red test lead to the V-Ω jack. Short the test leads together.

c. Set the RANGE switch to the AUTO position.

d. Depress the DC-Ω and HI PWR Ω switches.

e. Open the test leads. The Most Significant Digit (MSD) display will be flashing the digit "2" in the out-of-range condition, with the other digits blanked. The "MΩ" indicator will be illuminated.

f. Short the test leads together. The display reading will return to .000 ±1 digit. The "MΩ" indicator extinguishes; the "KΩ" indicator illuminates.

g. If difficulty is encountered in the above steps, refer to Section VI.

4.5 DC VOLTAGE MEASUREMENTS

a. Review the safety precautions in paragraph 4.2.

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Depress the DC-Ω switch.

d. Depress the V switch.

CAUTION

To avoid possible damage to the Instrument, the input voltage must not exceed 1000 VDC.

e. Turn off the power to the device or circuit under test and discharge all capacitors.

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The Instrument automatically measures and displays voltages from ±.0001 VDC to ±1000 VDC with maximum resolution. A minus sign (—) is used to indicate negative polarity. If the minus sign is off, a positive polarity is implied.

	PUSHBUTTONS DEPRESSED								INPUT CONNECTIONS			
FUNCTION DESIRED	DC-Ω	AC	V	LO PWR	HI PWR	2 mA	10A 20mA	2 A	10A	mA-2A	COM-MON	V-Ω
DC Voltage	X		X								X	X
AC Voltage		X	X								X	X
Low Pwr Resistance	X			X							X	X
Std Pwr Resistance	X				X						X	X
DC Current .2-2mA	X					X				X	X	
DC Current 20mA	X						X			X	X	
DC Current .2-2A	X							X		X	X	
DC Current 10A	X						X		X		X	
AC Current .2-2mA		X				X				X	X	
AC Current 20mA		X					X			X	X	
AC Current .2-2A		X						X		X	X	
AC Current 10A		X					X		X		X	

Table 4-1. Summary of Function Setting and Input Connections

h. Depress the RANGE switch to the HOLD poistion for repetitive measurements in a single range. In this mode, overrange condition ($\geqq$ 2000 counts) is indicated by flashing of the display, with the numeral "2" appearing in the MSD digit position.
i. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.
j. Switch selections and input connections are summarized in Table 4-1.

4.6 AC VOLTAGE MEASUREMENT

a. Review safety precautions in paragraph 4.2.
b. Connect input test leads to the V-Ω and COMMON terminals.
c. Depress the AC switch.
d. Depress the V switch.

CAUTION

To avoid possible damage to the Instrument, the input voltage must not exceed 600 VAC.

e. Remove all power from the circuit being measured and discharge all capacitors.
f. Connect test leads to the circuit being measured.
g. Apply power to the circuit being measured. The Instrument automatically measures and displays voltages from .0001 VAC to 600 VAC with maximum resolution.
h. Depress the RANGE switch to the HOLD position for repetitive measurements in a single range. In this mode, overrange condition ($\geqq$ 2000 counts) is indicated by flashing of the dis-

play, with the numeral "2" appearing in the MSD digit position.

i. Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.

j. Switch selection and input connections are summarized in Table 4.1.

4.7 RESISTANCE MEASUREMENTS

4.7.1 GENERAL

The 465-2 measures resistance from 1Ω to 20MΩ in two overlapping modes — LOW POWER OHMS and HI POWER OHMS. The LO POWER OHMS mode is useful for measurements which require low power dissipation, low voltage drop across the resistance, and low open-circuit voltages (less than 350mV). These features are especially desirable for in-circuit resistance measurements which require non-conduction of semiconductor junctions. The low open-circuit voltage in the LO POWER OHMS mode eliminates the possibility of damaging certain semiconductor junctions. The HI POWER OHMS is useful for measurements which require a higher voltage across the resistance, such as testing conduction in transistors and diodes.

4.7.2 MEASUREMENT PROCEDURE

a. Review the Preliminary Notes and Checks in paragraph 4.2.

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Depress the DC-Ω switch.

d. Depress either the HI PWR/Ω or LO PWR/Ω switch.

e. If the resistance being measured is connected into a circuit, be certain that all power is removed from the circuit and all capacitors are discharged. Check for current paths other than through the resistance being measured. These paths can result in a measured value which is lower than the actual value of the resistance being measured.

f. Connect the test leads to the resistance being measured. Be careful not to contact adjacent points, even if insulated, particularly when making high resistance measurements. Some insulators can have relatively low insulation resistance, which can sufficiently shunt the resistance being measured to result in a measured value lower than the presumed value.

> **NOTE:** If the resistance being measured is polarity or voltage sensitive (for example, semiconductors), careful considerations must be given when making connections and selecting the resistance range (paragraph 4.8).

g. The Instrument automatically measures and displays resistances from .001 kΩ to 20 MΩ.

h. Depress the RANGE switch to the HOLD position for repetitive measurements in a single range. In this mode, overrange condition ($\geqq$ 2000 counts) is indicated by flashing of the display, with the numeral "2" appearing in the MSD digit position.

i. Disconnect test leads.

j. Switch selections and input connections are summarized in Table 4-1.

4.8 SEMICONDUCTOR JUNCTION MEASUREMENTS

4.8.1 In order to measure semiconductor junction resistance, the measurement must be downranged to the lowest ohms range. This can be accomplished by performing the following procedure.

a. Review the safety precautions in paragraph 4.2.

b. Set the pushbutton switches for Hi Power Ohm measurements as indicated in Table 4-1.

c. Short the V-Ω and COMMON terminals. The Instrument shall

read .000 with "KΩ" indicator on.

d. Depress the HOLD switch so that the Instrument will stay in the 1 KΩ range.

e. To measure the forward resistance of a semiconductor junction, connect the cathode of the diode to the COMMON terminal and the anode to the V-Ω terminal. For silicon diodes, the Instrument should display .550 or higher. For germanium diodes, the Instrument should display .450 or lower.

f. To measure the reverse resistance of a semiconductor junction, the Instrument should display "overrange" (with reading flashing).

4.9 DC CURRENT MEASUREMENTS

a. Review the safety Precautions in paragraph 4.2.

b. Depress the DC-Ω switch.

c. Depress the appropriate current switch as indicated in Table 4-1. If current being measured is unknown (but less than 10A), begin with the 10A/20mA switch. Connect the red test lead to the 10A jack and the black test lead to the COMMON jack.

d. Remove all power to the circuit being measured and discharge all capacitors.

e. Open the circuit in which the current is to be measured and securely connect the test leads in series. Ensure that the 465-2 is not connected across a voltage source which can exceed ratings of the Instrument.

f. Apply power to the circuit being measured. The value of the current being measured will be indicated on the numerical display.

g. Depress the RANGE switch to the HOLD position for repetitive measurements in a single range.

h. Remove all power from the circuit being measured and discharge all capacitors.

i. Disconnect the test leads and reconnect the circuit which was originally opened.

4.10 AC CURRENT MEASUREMENTS

a. Review the Safety Precautions in Paragraph 4.2.

b. Depress AC switch.

c. Depress the appropriate current switch as indicated in Table 4-1. If the current being measured is unknown (but less than 10A), begin with the 10A/20mA switch. Connect the red test lead to the 10A jack and the black test lead to the COMMON jack.

d. Remove all power to the circuit being measured and discharge all capacitors.

e. Open the circuit in which the current is to be measured and securely connect the test leads in series. Ensure that the 465-2 is not connected across a voltage source which can exceed ratings of the Instrument.

f. Connect the test leads according to Table 4-1.

g. Apply power to the circuit being measured. The value of the current being measured will be indicated on the numerical display.

h. Depress the RANGE switch to the HOLD position for repetitive measurements in a single range.

i. Remove all power from the circuit being measured and discharge all capacitors.

j. Disconnect the test leads and reconnect the circuit which was originally opened.

SECTION V
THEORY OF OPERATION

5.1 GENERAL

5.1.1 This section describes the theory of operation of the 465-2. All modes of operation are described first; then, description of the circuit follows.

5.2 OVERALL SYSTEM

5.2.1 The basic system block diagram for the 465-2 is shown in Figure 5-1.

5.2.2 Signal Conditioning Section:

5.2.3 The parameter being measured is connected to the appropriate input terminals. The corresponding Signal Conditioning circuits convert this parameter into a proportional DC voltage. The conversion is accomplished by the Autoranging Amplifier. Current Shunts, Resistance Converter, AC-to-DC Converter, and associated switching.

5.2.4 Analog-To-Digital Converter Section:

5.2.5 The Analog-To-Digital (A/D) Converter section changes the DC output voltage from the Signal Conditioning section to digital information.

5.2.6 Display Section:

5.2.7 Through the Segment and Anode Drivers, the digital information from the A/D converter is indicated on the 7-segment Numerical Display.

5.3 INPUT CIRCUITS

5.3.1 DC Voltage Measurements:

5.3.2 The basic DC voltage measurement circuit is shown in Figure 5-2. The DC voltage being measured is connected to the

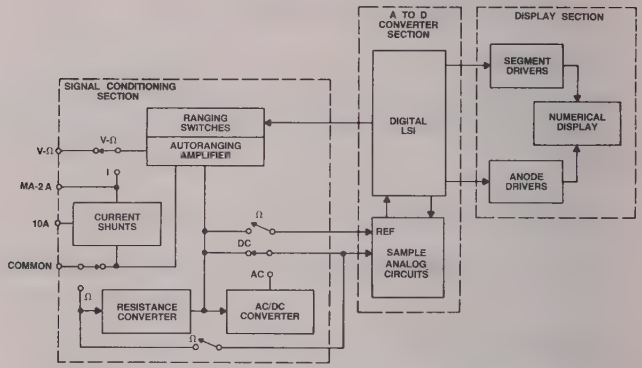


Figure 5-1. Basic System Block Diagram

V-Ω and COMMON jacks, attenuated according to the range selected and converted into a scale DC voltage by the Autoranging Amplifier. The amplifier has a gain of X10 on the 0.2V range decreasing to X0.001 on the 1000V range. The gain of each range is determined by the feedback resistor as shown in Table 5-1.

5.3.3. The various amplifications of the Autoranging Amplifier are determined automatically by the Simpson LSI chip. Since the input resistance has a constant value (10 MΩ)the source loading does not vary from range to range.

Table 5-1. Autoranging Amplifier Gain vs. Feedback Resistance

Range	Gain	Equivalent Feedback Resistance
.2 V	X 10	100 MΩ
2 V	X 1	10 MΩ
20 V	X .1	1 MΩ
200 V	X 0.01	100 kΩ
1000 V	X 0.001	10 kΩ

5.3.4 AC Voltage Measurements:

5.3.5 The basic AC voltage measurement circuit is shown in Figure 5-2.

5.3.6 The AC voltage being measured is connected to the V-Ω and COMMON jacks, attenuated according to the range selected by the Autoranging Amplifier and the AC to DC Converter in Table 5-2.

Table 5-2. AC Voltage Amplification Gain Arrangement

Range	Amplification Gain	
	Autoranging Amplifier	AC-DC Converter
.2 V	X 1	X 10
2 V	X 1	X 1
20 V	X 0.1	X 1
200 V	X 0.01	X 1
600 V	X 0.001	X 1

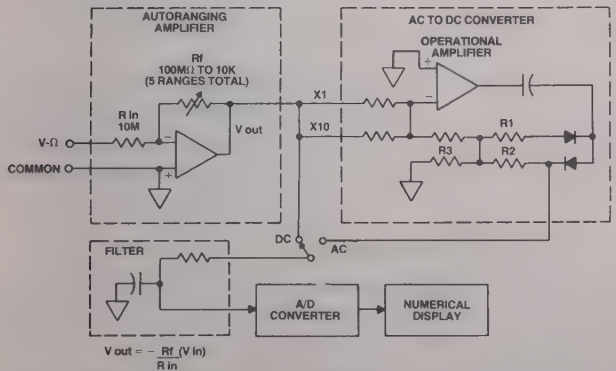


Figure 5-2. Basic Voltage Measurement Circuits

5.3.7 The Autoranging Amplifier is frequency-compensated to provide accurate readings over a wide frequency range.

5.3.8 The AC to DC Converter uses a half-wave operational amplifier/rectifier circuit which provides two basic full range sensitivities: 200 mV and 2V. It is average responding, but its calibration (gain) is based on the rms value of a sine wave.

5.3.9 The output of the Operational Amplifier has two rectifying diodes and two feedback resistors, R1 and R2. These components drive a summing resistor R3. The junction of the summing resistor and feedback resistors is connected to the amplifier input to provide negative feedback. With a sine wave input signal, the positive half cycles of the output waveform go through one diode, and the negative half cycles through the other diode. The positive half cycle is filtered and the resulting DC voltage is measured by the A/D Converter.

5.3.10 The indications of the numerical display are calibrated to the rms sine wave value being measured.

5.3.11 AC Current Measurements:

5.3.12 The basic AC current measurement circuit is essentially the same as the DC current measurement circuit (paragraph 5.3.13), except that the voltage developed across the internal shunt resistance is measured by the AC voltage measurement circuit.

5.3.13 DC Current Measurements:

5.3.14 The basic DC current measurement circuit is shown in Figure 5-3, (a).

5.3.15 The current being measured is connected in series with the COMMON and the mA 2A (or 10A) jacks and an internal

precision shunt resistance. The value of the shunt resistance depends on the current range used and is selected so that the voltage developed across it is proportional and numerically equal to the current through it. This voltage is being measured by the DC voltage measurement circuit and the value indicated on the numerical display is equal to the current being measured.

5.3.15 Resistance Measurements:

5.3.16 The basic resistance circuit is shown in Figure 5-3, (b).

5.3.17 The resistance being measured, Rx, is connected to the V-Ω and COMMON jacks. A voltage ratio is made by comparing the unknown resistance (Rx) with an internal standard resistance (Rf). The voltage ratio is applied to the A/D Converter to yield a numerical value which is proportional to the unknown resistance

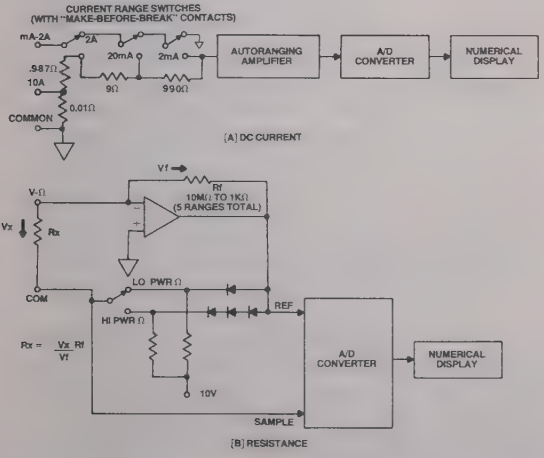


Figure 5-3. Basic DC Current and Resistance Measurement Circuits

as shown in Figure 5-3, (b). The ranges of the resistance measurement circuit are determined by the feedback resistors which are selected automatically by the Simpson LSI chip.

5.3.18 When the Instrument is set for LO PWR OHMS measurements, the maximum voltage across the input terminals is clamped by a germanium diode so the maximum open-circuit voltage is less than 350 mV.

5.3.19 When the Instrument is set for HI PWR OHMS measurements, the maximum voltage across the input terminals is clamped by three silicon diodes connected in series, so the maximum open circuit voltage is less than 2.5 volts.

5.4 A/D CONVERTER

5.4.1 The basic block diagram of the A/D Converter is shown in Figure 5-4. The circuit utilizes the "Up-Down" integration technique for the analog-to-digital conversion. This technique is based on the conversion of a DC voltage into a proportional time period. The converter initially accumulated a charge proportional to the input signal on an integrating capacitor (C2) for a fixed period of time. In the second integration period, the capacitor discharges back to the "zero" voltage starting point, when the input signal is removed and a reference voltage opposite in polarity is placed at the input of the converter. The ratio of the time required to remove the integrator charge to the initial fixed time period is proportional to the amplitude of the input DC voltage.

5.4.2 The A/D converter requires three periods of integration for each measurement. During T_0, the AUTO ZERO period, converter error is stored on C_1. Next the input signal (Ein) is integrated in period T_1. Finally, in T_2, the reference signal is integrated which returns the integrator to zero and thereby ending the conversion cycle. The next conversion is initiated by the

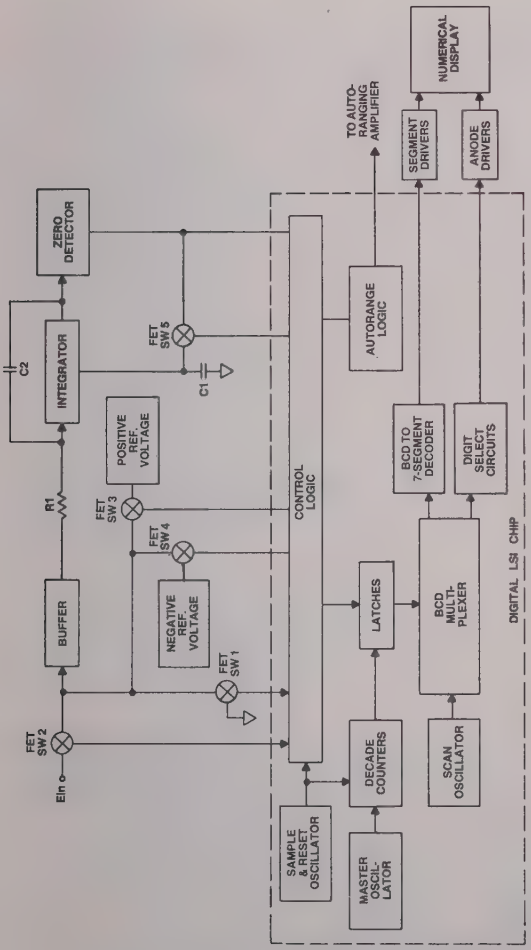


Figure 5-4. A/D Converter Block Diagram

Sample and Reset Oscillator as shown in (1) of Figure 5-5 (Basic Timing Diagram).

5.4.3 The pulse resets the Decade Counters to "zero" and the trailing edge of the pulse ends the period T_0 and initiates period T_1. During T_1, the DC voltage Ein is sampled, and the Integrator generates a ramp whose slope is proportional to the value of the input signal. Also during T_1, the Master Oscillator (2) produces pulses which are counted by the Decade Counters until a total of 1,000 counts is accumulated. At this moment, period T_1 ends and T_2 begins.

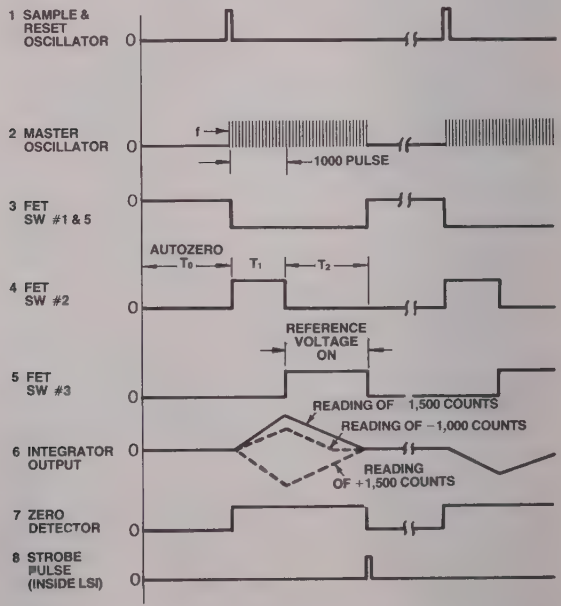


Figure 5-5. Basic Timing Diagram

5.4.4 During T_2, the input signal is removed, and a reference voltage of the opposite polarity is connected to the Integrator input. The Integrator at this time produces a ramp toward the starting point with a fixed slope as shown in (6) of the timing diagram. When the Integrator output has reached the "zero" voltage starting point, the Zero Detector changes states. At this point the reference voltage is removed and the Control Logic inhibits the Master Oscillator.

5.4.5 The count stored in the Decade Counters is in turn transferred to the Latches via a strobe pulse (8) generated by the Control Logic. The BCD information is then multiplexed, decoded into 7-Segment information, and numerically displayed through the Segment and Anode Drivers.

5.4.6 The other requirements of the A/D Converter such as overrange and polarity indications are accomplished by the Control Logic and Counter Circuits.

5.5 AUTORANGING CIRCUITRY

5.5.1 Located in the Simpson LSI module, the autoranging circuitry consists basically of a five stage bidirectional ring counter and logic gate for up/down control.

5.5.2 The ring counter will shift up, down, or stay in a certain range as determined by the up-range (greater than 2000 counts) or down-range (less than 180 counts) signal. The outputs of the ring counter are used to control the gain of the Autoranging Amplifier. For example: applying a signal of .170 volts in the 2V DC range will cause the ring counter to shift down to the .2V range and display .1700V at the next conversion cycle. Likewise, applying a signal of 2.2 volts in the 2V DC range will cause the ring counter to shift up to the 20V range and display 2.20V at the next conversion cycle.

5.5.3 Through logic circuitry in the LSI module, down-ranging from the lowest range or up-ranging from the highest range is prohibited.

5.5.4 When the "HOLD" function is used, the Instrument is prohibited from either up-ranging or down-ranging. It will stay in the range when the HOLD pushbutton is depressed.

5.5.5 The decimal point output is automatically decoded through the ranging signals, the digit select signals and function inputs.

5.6 POWER SUPPLY CIRCUITS

5.6.1 AC Line Power:

5.6.2 The AC line power supply is shown in Figure 7-2, Schematic Diagram. The incoming AC power is applied to the primary power transformer T101. The primary winding is tapped for 240 VAC, 220 VAC and 120 VAC operation. The secondary windings generate step-down voltages to provide 3 regulated DC voltages.

5.6.3 Regulated DC voltages of +10V and —10V are produced by two full-wave rectifiers, followed by two series-type voltage regulators. These regulated voltages are used to supply power to the analog circuits.

5.6.4 A full-wave rectifier, followed by a series-type voltage regulator, provides a regulated +5V supply to all digital integrated circuits and the LED display.

5.6.5 Battery Power (465D-2 only):

5.6.6 The battery-operated power supply of the 465D-2 is shown on Figure 6-2, Schematic Diagram. With the POWER switch ON, the battery is connected to the input of the DC-To-DC converter consisting essentially of transformer T301 and transistors

Q301 and Q302 in a multivibrator configuration. The multivibrator signal is coupled by T301 to the bridge rectifier and regulators to generate DC voltages of +10V DC and —10V DC. The required +5 volt supply is provided by the battery.

5.6.7 The battery is charging whenever the 465D-2 is connected to the AC line source. The charging circuitry consists of D28 and R107 and provides a charging current of approximately 400 milliamperes when the Instrument is OFF. Approximately 50 milliamperes is supplied through the +5V regulator (Q40) to charge the battery when the Instrument is ON.

5.6.8 When the 465D-2 is operated with AC line power (no battery power) the regulator (Q5) provides the +5V supply required for operation.

WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

SECTION VI
SERVICING INSTRUCTIONS

6.1 GENERAL

6.1.1 The 465-2 is carefully designed and constructed with high quality components. By providing reasonable care and following the instructions in this manual, the user can expect a long, useful service life from his Instrument.

6.2 COVER REMOVAL

6.2.1 The bottom cover can be removed for servicing purposes by the following procedures:

WARNING

Remove all power and connections to the Instrument before removing the case cover. Do not operate the Instrument with the bottom cover removed.

a. Depress the POWER switch to the OFF position.
b. Disconnect the line cord from the power source and all connections from the Instrument.
c. Pull out the knobs on sides of Instrument and raise the handle towards the rear of Instrument.
d. Turn the Instrument over and remove the four (4) screws within the rubber feet.
e. Lift bottom cover and remove handle.
f. Reverse this procedure when replacing the cover.

6.3 BATTERY INSTALLATION (465D-2 only)

6.3.1 Refer to Table 6-2 for recommended batteries.

CAUTION

To avoid dangers associated with recharging batteries, use only the type specified in Table 6-2. Do not attempt to use cadmium zinc, alkaline or the like that is not designed to be recharged.

6.3.2 Install the cells as follows:

a. Remove bottom cover (paragraph 6.2). Remove the retainer tubings from the battery holder. Insert two cells into each retainer. Then install the combination into the holder. Ensure that the cells are installed according to the polarity orientation designated on the battery holder label. Failure to do so can damage the 465D-2.

b. Check that the battery contacts are clean and making good connection.

c. Replace the bottom cover.

d. For battery recharging, refer to paragraph 6.4, below.

e. Test the battery according to paragraph 4.3.2.

6.4 BATTERY CHARGING (465D-2 only)

6.4.1 The battery is being charged at full rate when the POWER switch is set to the OFF position and AC power is applied to the Instrument. Approximately 16 hours are required to fully charge the battery in this mode of operation.

NOTE: If the battery voltage checks below +4.7 volts, charge the battery with the POWER switch set to OFF for at least 15 minutes before operating the Instrument.

6.4.2 The battery is being "trickle" charged whenever the Instrument is operated by the AC powerline.

6.5 BATTERY CARE

6.5.1 Avoid discharging the cells completely. Check the battery voltage periodically using the BATTERY TEST jack (paragraph 4.3.2). Charge the battery whenever the voltage is close to or below +4.7 volts.

6.5.2 Do not operate the Instrument with discharged cells. Make sure to recharge all newly purchased batteries (paragraph 6.4) for at least 15 minutes before operating the Instrument.

6.5.3 Whenever the line cord is not connected and the Instrument is not in use, remember to set the POWER switch to the OFF position.

6.5.4 With nickel-cadmium cells installed in the 465D-2, avoid storing in an area where the temperature exceeds +60°C.

6.6 FUSE REPLACEMENT

6.6.1 The line and current fuses are mounted inside fuseholders on the main P.C. Board as shown in Figure 6-1. Use the following procedure to replace a fuse.

WARNING

Remove all power and input connections to the Instrument before removing bottom cover. Do not replace a blown fuse with a fuse which has a larger rating or slower time lag characteristic than those specified.

a. Remove bottom cover as described in paragraph 6.2.
b. Carefully lift the defective fuse from the holder and replace with appropriate fuse (Table 6-2).
c. Replace the bottom cover.

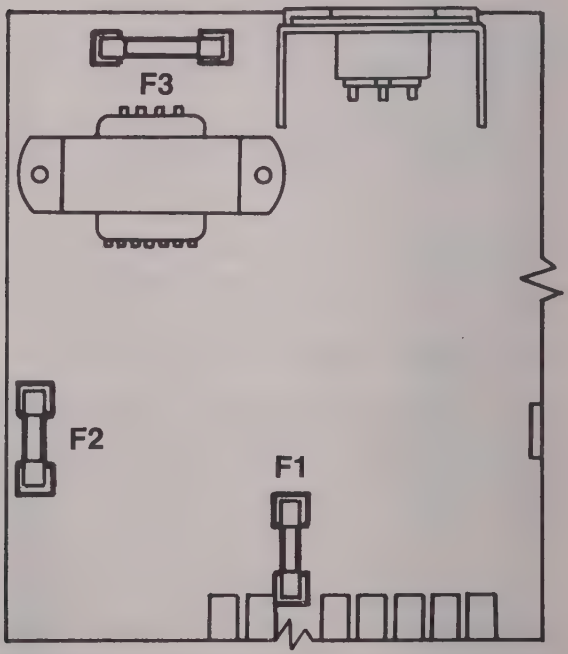


Figure 6-1. Fuse Location

6.7 TROUBLESHOOTING:

6.7.1 If the Instrument does not yield satisfactory results, follow this procedure, (and Troubleshooting Chart Table 6-1) before attempting servicing on the Instrument:

a. Review and comply with the Preliminary Notes and Checks, listed in paragraph 4.3.

b. Check the position on all switches for the parameter and range of value being measured and that the measurement situation is within the ratings of the Instrument.

c. If the 465A-2 has been operated with AC power ensure that the power source is within the Instrument specifications, and free from excessive fluctuations and transients.

d. If the 465D-2 has been operated with battery power, be sure that the cells are charged and properly installed (paragraph 6.4).

e. Ensure that the environment in which the Instrument is being used is within the Instrument specifications.

f. Inspect the device being measured and the measurement test set-up to ensure that proper shielding and grounding techniques have been used. Also, consider whether the Instrument is significantly affecting the circuit being measured.

6.7.2 If the steps taken in paragraph 6.7.1 do not yield satisfaction, refer to the troubleshooting chart (Table 6-1). Direct all other repair and adjustment needs to an Authorized Service Center. (A list of these centers appears at the back of this manual.)

Table 6-1. Troubleshooting Chart

Symptom	Probable Causes	Cure
1. No indication on numerical display when 465D-2 is battery operated. AC operation is allright.	Cells - Discharged, defective, not installed properly, making poor contact, or missing.	Check battery voltage. Refer to para. 4.3.2. If OK contact nearest Authorized Service Center.
2. LOW intensity on numerical display in battery operation (465D-2).	Cells not fully charged.	Check battery voltage (para. 4.3.2). If battery checks low, remove cover and check that the cells are installed correctly and making good contact (para. 6.4). If they are, replace cover and charge battery overnight (para. 6.5).
3. No indication on the numerical display when Instrument is AC line operated (no cells installed).	a. Low or no voltage at power source receptacle. b. Line cord disconnected. c. Defective line cord. d. Line fuse open.	a. Restore correct voltage at power receptacle. b. Connect line cord. c. Repair or replace. d. Replace line fuse (para. 6.6).
4. Batteries do not respond to charge. 465D-2 operation acceptable when connected to AC power.	Cells defective, not installed properly, making poor contact, or missing.	Remove cover and check that cells are installed correctly and making good contact (para. 6.4). If they are, check the voltages of the individual cells. Replace those which check significantly lower than normal (1.25 volts).

Symptom	Probable Causes	Cure
5. Operation normal on all functions and ranges except AC and DC Current.	Current fuse F1 or F2 open.	Replace fuse (para. 6.6).
6. Indications fluctuate and/or drift, even though indication is OK at 000 with the input terminals shorted, and at 1000 counts when using a stable and low impedance input.	Fluctuations and/or drift are being generated by the device being measured or the measurement test set up.	Use proper shielding, grounding techniques and connections to minimize "pick-up" of unwanted signals due to ground loops, poor connections, and capacitive and/or inductive coupling. Operate Instrument (465D-2 only) on battery for complete isolation from the powerline. NOTE: If the drift and/or fluctuation is coming from the device being measured, no cure is required, the measurement is valid, and the device must be corrected.
7. Indication is allright on battery; however, on AC operation, the reading fluctuates and/or drifts at 0, with the input shorted, and/or at 1000 counts using a stable and low impedance input. (465D-2)	AC power source is low or fluctuating (including transients).	Correct the power source or use Instrument on battery.
8. Same as 7 above, except indication acceptable on AC, but not battery operation.	a. Battery voltage low.	a. Check battery condition. Refer to para. 4.3.2. If allright charge bat-

Symptom	Probable Causes	Cure
		tery, refer to para. 6-4.
	b. One or more cells defective, not installed correctly.	b. Remove cover and check that cells are installed correctly and making good contact. If allright, replace all cells temporarily with conventional carbon zinc "D" size cells for checking purposes only. If problem still exists, contact nearest Authorized Service Center for instructions.
9. Slow response. Operation allright when using a low impedance input.	Parameter being measured has a high source impedance.	None required.
10. Accuracy not within specifications when checked with a stable, higher accuracy (at least 5 times better) low impedance (voltage measurements) source.	a. Instrument is out of calibration. b. Instrument not zeroed properly.	Contact nearest Authorized Service Center.
11. Accuracy of Instrument is within specifications but measurements appear in error.	a. Instrument affects circuit being measured. b. Common and/or normal mode specifications is being exceeded.	a. Study circuit being measured vs Instrument specifications. Correct indications accordingly. b. Refer to cure in step 6 above.

6.8 REPLACEMENT PARTS AND SCHEMATIC DIAGRAM

NOTE: This instrument must be serviced by qualified personnel. To aid in troubleshooting a schematic diagram is enclosed. The accompanied parts list (Table 6-2) describes the components and refers to Simpson part numbers. Reference Symbol numbers correlate the components shown on the schematic diagram with the parts list.

6.8.1 The following information is provided as an adjunct to the overall text contained in this manual and should be read and understood thoroughly prior to ordering replacement parts for the Instrument.

6.8.2 To obtain replacement parts, address order to the nearest Authorized Service Center (listed on the last pages of this manual). Refer to paragraph 2.3.1 for ordering instructions.

Table 6-2. Replacement Parts

( ) = Parts used on 465A-2 only.

[ ] = Parts used on 465D-2 only.

All other parts are common to both models.

Reference Symbol	Description	Part No.
	Battery, "D" size, 1.25V, 4-Ampere-Hrs, Nickel-Cadmium, Eveready Type CH4 Rechargeable, or Equal	*

**Available at local electronic parts distributors.*

Reference Symbol	Description	Part No.
F1	Fuse, Current, 2A 250V type 3AG, Normal-Blow	1-112911
F2	Fuse, Current, 1/32A 250V type 3AG, Normal-Blow	5-119397
F3	Fuse, Line (for 120 VAC operation)	1-113835
	¼A 250V type 3AG, Normal-Blow (for 220/240 VAC operation)	1-116104
	⅛A 250V type 3AG, Normal-Blow	
[F4]	Fuse, 3.0A, 125 V, Quick Acting Pico Fuse	5-115486
	Pushbutton, Black	5-119378
	Pushbutton, Red	5-118379
	Pushbutton, Gray	5-118086
	Pushbutton, White	5-119393
	Alligator Clips, without insulators	1-115963
	Insulator, alligator clip, red	5-112479
	Insulator, alligator clip, black	5-111169
	Case Assembly Top	10-863560
	Case Assembly Bottom	10-863561
	Handle Molded	5-118375
	Handle Insert	5-118398
	Holder, Battery	5-118399
	Rubber, Foot	1-117829
	Screw, Rubber Foot	5-144572
	Spacer, Flex	5-328427
C1,2,40,43, 302,304	Capacitor, 0.1μF ±20%, 50V	5-113215
C3,4,16,17,46	Capacitor, 1.0μF ±10%, 35V	5-116713
C5,6,18,19,45	Capacitor, 2.2μF ±10%, 35V	5-119385
C7	Capacitor, .1μF ±20%, 100V	5-113612
C8,20	Capacitor, 18pF ±5%, 1kV	5-119577

Reference Symbol	Description	Part No.
C9,10,22,36, 37,47,48, 50,55	Capacitor, 15μF, 16V	5-115534
C11,12	Capacitor, .1μF, 20V	5-114521
C23	Capacitor, 100pF ±20%, 1kV	5-113217
C14	Capacitor, 100pF ±5%, 500V	5-118748
C15	Capacitor, 3300pF ±5%, 33V	5-117586
C21	Capacitor, Variable, 1-5.5pF	5-119544
C24	Capacitor, 207pF ±1%, 25V	5-117570
C25	Capacitor, Variable, 2-22pF	5-119576
C26,29,31,32	Capacitor, .02μF, 600V	1-117367
C27	Capacitor, 2290pF ±1%, 63V	6-110421
C28	Capacitor, Variable, 5.5-60pF	5-116235
C30	Capacitor, .0220μF ±1%, 63V	5-119389
C33	Capacitor, 23pF ±1%, 1kV	5-119413
C34,38,13	Capacitor, 330pF ±20%, 500V	5-112690
C35	Capacitor, .01μF, GMV, 1kV	5-119414
IC1	Integrated Circuit, Op. Amp., CA3140T	5-119184
IC2	Integrated Circuit, Op. Amp., LM308N	5-116598
IC3	Integrated Circuit, Op. Amp., LM318N	5-119187
IC4	Integrated Circuit, A/D Digital LSI	5-118744
IC5,6,7,8	Integrated Circuit, Qual 2 Input Gate, DM74C00	5-118133
IC9	Integrated Circuit, Op. Amp., 3522K	5-119373
IC10	Integrated Circuit, Op. Amp., LM709CH	5-113642
DS1,2,3,4,5	Readout, LED, 7-Segment	5-119396
Q1,2,3,4,5,6	Transistor, FET, N-Channel 2N5458	5-112747

Reference Symbol	Description	Part No.
Q7,8,9,16, 18,19,20,21, 22,23,24,25, 26,34,35,38	Transistor, Silicon PNP, 2N4248	5-115484
Q10,11,32,33, 37,[303,304, 305]	Transistor, Silicon NPN, 2N4123	5-115931
Q12,13,14,15	Transistor, FET, N-Channel, 2N4392 Selected	5-119374
Q17	Transistor, FET, N-Channel, 2N4392	5-119375
Q27,28,29, 30,31	Transistor, Silicon PNP, MPS3638A	5-119376
Q36	Transistor, Silicon NPN, 2N2219A	5-117062
Q39	Transistor, Silicon PNP, 2N2905	5-116512
[Q40]	Transistor, Silicon NPN, D40D1	5-117342
[Q301,302]	Transistor, Silicon NPN, GET 2222	5-115934
C39,44	Capacitor, 22μF ±30%, 16V, N.P.	5-119531
C41	Capacitor, 56pF ±20%, 1kV	5-110934
C42	Capacitor, 4.7pF ±5%, 1kV	5-114988
C49	Capacitor, 47μF —10 ±5%, 16V	5-119388
(C51A)	Capacitor, 4700μF, 10V	5-118083
[C51D]	Capacitor, 2200μF, 16V	5-118084
[C52,53]	Capacitor, 2200μF, 25V	5-119386
[C301]	Capacitor, 100μF, 10V	5-117050
C305	Capacitor, 10μF, 25V	5-118426
C306,307	Capacitor, 10μF, 25V	5-119387
D1 thru D21 except D11, 12,17	Diode, Silicon, 1N914	5-112004
D11,12	Diode, Silicon, 1N5059	5-113826
D17	Diode, Germanium, 1N34	1-115392

Reference Symbol	Description	Part No.
D22,23,(24, 25,26,27), [28,301],[302, 303,304]	Diode, Silicon, 1N4002	5-113201
D201,202	Diode, Light Emitting, Red	5-119411
ZD1,2	Diode, Zener, 1N4576	5-116201
ZD3,4	Diode, Zener, DZ202, 15A	5-116203
ZD301	Diode, Zener, 1N747A	5-113817
R1,5	Resistor, 1.37kΩ ±1%, ¼W	5-119574
R2,6	Resistor, 8.2kΩ ±1%, ¼W	5-119575
R3,7	Potentiometer, 200Ω, Cermet	5-119827
R4,8	Resistor, 1.37kΩ ±1%, ¼W	5-117188
R9,10,28,62, 65,66	Resistor, 10kΩ ±1%, ¼W	5-114962
R11,12,13,24, 39,40,41,42, 44,46,49,57, 58,94	Resistor, 100kΩ ±10%, ¼W	5-115514
R14,52	Resistor, 110kΩ ±1%, ¼W	5-117519
R15,16	Resistor, 1.0kΩ ±1%, ¼W	5-115490
R17,19,95,96, [305]	Resistor, 5.1kΩ ±5%, ¼W	5-117714
R18	Resistor, 2.25MegΩ ±1%, ½W	5-118342
R20,26	Resistor, 300kΩ ±5%, ¼W	5-115439
R21,23,25,34, 48,59,83,89, 90,93,98,100	Resistor, 10kΩ ±10%, ¼W	5-113624
R22,103,104, 202,203	Resistor, 560Ω ±5%, ¼W	5-116094
R27	Potentiometer, 10kΩ, Cermet	5-118081
R29	Potentiometer, 1MegΩ, Carbon	5-119377

Reference Symbol	Description	Part No.
R30,101	Resistor, 1MegΩ ±5%, ¼W	5-119380
R31	Resistor, 22MegΩ ±5%, ¼W	5-118424
R32,33,67,68	Resistor, 20kΩ ±1%, ¼W	5-116621
	Resistor, Matched Set, 8 Resistors	
R35	9.991 MegΩ, ½W	
R36	10kΩ, ½W	
R37	90kΩ, ½W	
R38	11.11 MegΩ, ½W	5-119382
R43	1.01007 MegΩ, ½W	
R45	100.07 kΩ, ½W	
R47	9.971kΩ, 1W	
R51	10 MegΩ, 2W	
R50	Resistor, 1.0kΩ ±.1%, ¼W	5-115489
R53	Resistor, 1.0MegΩ ±1%, ¼W	5-117693
R54	Resistor, 100Ω ±1%, ¼W	5-116164
R55	Potentiometer, 500Ω, Cermet	5-118763
R56	Resistor, 10.7kΩ ±1%, ¼W	5-116628
R60	Resistor, 1.5kΩ ±5%, ¼W	5-119381
R61	Resistor, 100kΩ ±1%, ¼W	5-115488
R63	Potentiometer, 100Ω, Cermet	5-119044
R64	Resistor, 510Ω ±1%, ¼W	5-115488
R69	Resistor, 3.0kΩ ±5%, ½W	5-111405
R70	Resistor, 990Ω ±.1%, 1W	5-119378
R71	Resistor, 9.0Ω ±.1%, ¾W	5-115576
R72,73	Resistor, 11kΩ ±5%, ¼W	5-117216
R74,75,76,77, 78,79,80,81	Resistor, 91Ω ±5%, ¼W	5-116365
R82	Resistor, 47kΩ ±5%, ¼W	5-113628
R84,85,86,87, 88	Resistor, 2.0kΩ ±5%, ¼W	5-115460
R91,92	Resistor, 100Ω ±5%, ¼W	5-117178

Reference Symbol	Description	Part No.
R97,99,[302], [303]	Resistor, 1kΩ ±10%, ¼W	5-113871
[R105]	Resistor, 30.1kΩ ±1%, ¼W	5-116621
[R106]	Resistor, 20kΩ ±1%, ¼W	5-115505
[R107]	Resistor, 6Ω ±10%, 5W	5-119561
R201	Potentiometer, 1MegΩ, Cermet	5-118765
R204	Resistor, 0.987Ω ±.1%, 5W	5-119379
[R301]	Resistor, 22Ω ±10%, ¼W	5-115509
[R304]	Resistor, 1Ω ±5%, ½W	5-119530
[R306]	Resistor, 510Ω ±5%, ¼W	5-114965
[R307]	Potentiometer, 10kΩ, Carbon	5-117535
[R308]	Resistor, 27kΩ ±5%, ¼W	5-118431
S1-10	Switch, pushbutton, 10 Station	5-119392
(T101A)	Transformer, Power, 465A	5-119390
[T101D]	Transformer, Power, 465D	5-119391
[T301]	Transformer, D.C. Converter	5-119545

NOTES

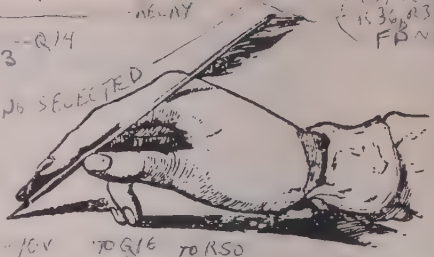
NOTES

R4 19=C
R3 20=0
R2 21=0

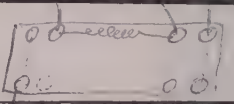
NOTES

FOR

THE RECORD



IF RELAY GOES UNDER TRY POTTED JUMPERS!



Date Purchased: _____

Purchased From: _____

Identification Number: _____

GO TO STANDBY BETWEEN EACH STEP AFTER STEP 4.

Date	Type of Service	Serviced By
1.	INPUT SHORT ADJ R201 FOR 0000	
2.	INPUT +1.9V ADJ R3 FOR +1.900	
3.	INPUT -1.9V ADJ R7 FOR -1.900	
4.	INPUT 1.9VAC 400HZ ADJ R63 FOR 1.900	
5.	INPUT .19VAC " " R55 FOR .190	
6.	INPUT 1.9VAC 10KHZ ADJ C21	
7.	" 19VAC " " C25	
8.	" 100VAC " " C28	

CHECK ALL [illegible]

U4 PIN 18=0V FOR 10K — H1 — Q15
R42 22=0 1K — 1K — RELAY
R4 19=0 100K — Q14
R3 20=0 1M — Q13
R2 21=0 10M — Q12
100 MΩ — NOTHING SELECTED

USING R36, R55, R37 FB NETWK

NOTES FOR THE RECORD

-10V TO R16 TO R50

IF RELAY GOES BAD TRY DOTTED JUMPERS!

RELAY BOTTOM VIEW

TO R51

Date Purchased: _____

Purchased From: _____

Identification Number: _____

GO TO STANDBY BETWEEN EACH STEP AFTER STEP 4.

Date	Type of Service	Serviced By
1.	INPUT SHORT ADJ R201	FOR 0000
2.	INPUT +1.9V ADJ R3	FOR +1.900
3.	INPUT −1.9V ADJ R7	FOR −1.900
4.	INPUT 1.9VAC 400HZ ADJ	R63 FOR 1.900
5.	INPUT .19VAC " "	R55 FOR .1900
6.	INPUT 1.9VAC 10KHZ ADJ	C21
7.	" 19VAC " "	C25
8.	" 100VAC " "	C28

CHECK ALL OHMS RANGES FROM 1K TO 10M

Rf / RIN

2VAC 2VAC

R63 R27 MASTER OSC. R55 SAMPLE OSC. R7 (-2V)

C21 C28 C25 R3 R201 ZERO

EXACT SUB FOR RELAY = TEK 148-0086-00

148-0107 PINOUTS RELAY SUB ALT. WIRE BOTH C AND BOTH NO TOGETHER FOR LOW OP.!

BAD (OPEN) RELAY WILL CAUSE LOCKUPS ON 100MΩ RANGE WITH 1K Ω AT INPUT.

PRINTED CIRCUIT BOARDS			
LAST USED	MAIN	READOUT	DC/DC CONVERTER
RESISTORS	R107	R204	R309
CAPACITORS	C54	—	C305
TRANSISTORS	Q40	—	Q305
DIODES	D28	D201	D304
ZENER DIODES	ZD4	—	ZD301

BATTERY VERSION ONLY (465 D)

NOTES:
1. UNLESS OTHERWISE SPECIFIED: RESISTORS IN OHMS; ±10%, ¼W; CAPACITORS IN μF; DIODES ARE IN914.
2. ALL SWITCHES SHOWN IN "OUT" POSITION.
SW1-HOLD SW6-HP(I)
SW2-AC SW7-2MA
SW3-DC-D SW8-20MA/10A
SW4-V SW9-2A
SW5-LP/I. SW10-POWER
3. USED ON LINE VERSION ONLY.
4. MAKE BEFORE BREAK CONTACTS.
5. FUSES ARE SHOWN FOR 120V OPERATION, 50-400 HZ. FOR 220V AND 240V OPERATIONS, USE 3AG./8A, NORMAL BLOW FUSE.
6. ANALOG COMMON (▽) AND DIGITAL COMMON (◆) ARE CONNECTED INTERNALLY.
7. ✱ DENOTES MATCHED SET.
8. ✱✱ DENOTES SELECTED PART.

R63 R55 R7 C21 C28 C25

ON 10V. VICE 5V.

Figure 6-2. Schematic Diagram

AUTHORIZED SERVICE CENTERS

SIMPSON ELECTRIC COMPANY

853 Dundee Avenue, Elgin, Illinois 60120 — Phone: (312) 697-2260

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★★ Parts, General Test Equipment & Panel Instrument Sales & Service
★★★ Same Service As (★★) Above Plus Panel Instrument Modification
★★★☐ Additionally Authorized for Service on Recorders, Controllers, Digital Products and Lab Portables

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YUKON RADIO SUPPLY, INC.
3222 Commercial Drive
P.O. Box 406
Tel. 907/277-1497

★**ALASKA, ANCHORAGE 99500**
R. M. ZOOK & ASSOCIATES
1710 E. 27th Avenue
Tel. 907/272-6917

★**ALASKA, FAIRBANKS 99701**
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Tel. 907/452-1011

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WESTERN ELECTRONIC SUPPLY CORP.
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5646 Jillson Street
Tel. 213/685-4340

★★★**CALIFORNIA, PALO ALTO 94303**
☐ METERMASTER, INC.
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★★★**CALIFORNIA, SAN DIEGO 92123**
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★★★**CALIFORNIA, SAN FRANCISCO 94105**
PACIFIC ELECTRICAL
INSTRUMENT LAB
150 Folsom
Tel. 415/543-3104

★★★**CALIFORNIA, SANTA CLARA 95050**
☐ FISHER-BROWNELL
3381 Edward Avenue
Tel. 408/988-6041

★★★**CALIFORNIA, SOUTH PASADENA 91030**
☐ ETALON COMPANY
1323 Huntington Drive
Tel. 213/257-5410

★★★**COLORADO, DENVER 80223**
☐ METER MASTER INSTRUMENT
CORPORATION
1165 S. Cherokee
Tel. 303/722-5766

★★★**CONNECTICUT, MIDDLETOWN 06457**
☐ THE MANCIB COMPANY
Subsidiary of E.I.L. Instruments
Randolph Road and Coe
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Tel. 305/635-9712

★★**FLORIDA, MIAMI 33136**
FLORIDA PRECISION INSTRUMENT
COMPANY
800 N.W. 7th Avenue
Tel. 305/324-1731

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307 27th St., Box 8945
Tel. 305/843-6775

★★**FLORIDA, TAMPA 33614**
TAMPA INSTRUMENTATION CENTER
A.C. FERNANDEZ ELECTRIC
4607 N. Church Avenue
Tel. 813/870-0183

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3020 Commerce Way
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EMC CORPORATION
2979 Ualena Street
Tel. 808/847-1138

★★**HAWAII, HONOLULU 96819**
KEMS INCORPORATED
239 Puuhale Road
Tel. 808/847-1395

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E.I.L. INSTRUMENTS, INC.
9708 Industrial Drive
Tel. 312/430-2292

★★★**ILLINOIS, ELK GROVE VILLAGE 60007**
METERMASTER, INC.
121 Gordon Street
Tel. 312/593-8650

★★★**ILLINOIS, OAK PARK 60302**
PACIFIC INDICATOR COMPANY
6603 W. North Avenue
Tel. 312/261-1330

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P.O. Box 6011 47712 (MAIL)
Tel. 812/423-5211

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★★★**KANSAS, WICHITA 67211**
☐ MAIN ELECTRONICS INC.
225 Ida
Tel. 316/267-3581

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☐ INDUSTRIAL INSTRUMENT WORKS
134 Laitram Lane
Tel. 504/733-6355

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5800 Main Street
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☐ PIONEER/INSTRUMENTATION
Div. of Pioneer Standard
Electronics Inc.
9100 Gaither Road
Tel. 301/948-0710

★★★**MARYLAND, SAVAGE 20863**
☐ INSTRUMENT SPECIALTIES INC.
Div. of Pyttronic Ind.
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Tel. 305/324-1731

★★★**MARYLAND, TIMONIUM 21093**
☐ E.I.L. INSTRUMENTS, INC.
1830 York Road
Tel. 301/252-1260

★★**MASSACHUSETTS, BILLERICA 01821**
METERMASTER, INC.
13 Fortune Drive
Tel. 617/667-8346

★★★**MASSACHUSETTS, BURLINGTON 01803**
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Subsidiary of E.I.L. Instruments Inc.
21 "A" Street
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★★★**MICHIGAN, FERNDALE 48220**
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★★★**MINNESOTA, MINNEAPOLIS 55427**
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LABORATORIES CORP.
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7170 Manchester
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★★**NEBRASKA, LINCOLN 68508**
ELECTROMETRICS COMPANY
404 South 11th
Tel. 402/477-3434

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PLAINFIELD 07080
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500 Hadley Road
Tel. 201/753-4600

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830 Haines Avenue NW
Tel. 505/243-6772

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MOHAWK COMMUNICATIONS
3500 Bleachery Place
Tel. 315/737-7328

★★★**NEW YORK, CHADWICKS 13319**
MOHAWK COMMUNICATIONS
3500 Bleachery Pl.
Tel. 315/737-7328

★★★**NEW YORK, CLARENCE 14031**
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9020 Wehrle Drive
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